國立中山大學100學年度碩士班招生考試試題

科目：有機化學【材光系碩士班甲組】

1. 選擇題 (單選, total 40%, each 2%)

1) ( ) How many sets of equivalent hydrogen atoms are there for 2-propanol?
a) 2 b) 3 c) 4 d) 8.

2) ( ) Which of the following molecules would you expect to be nonpolar?
I. CH_2Cl_2 II.. CO_2 III.. CCl_4 IV. CH_3OCH_3
a) I and II b) I and III c) I and IV d) II and III.

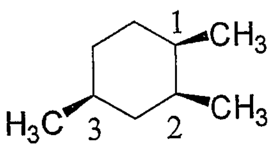
3) ( ) In which of the following bond dipole, the oxygen is located on the positive end? a) O-N, b) O-S, c) O-F, d) O-H.

4) ( ) which one of the following is chiral? a) 1,1-Dibromo-1-chloropropane, b) 1,1-Dibromo-3-chloropropane, c) 1,3-Dibromo-1-chloropropane, d) 1,3-Dibromo-2-chloropropane

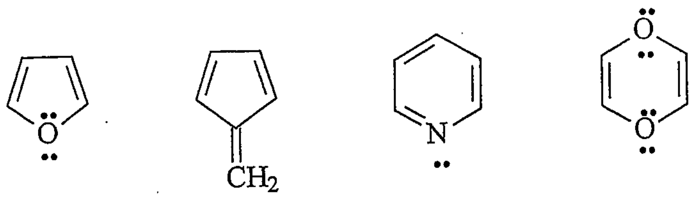
5) ( ) Which is the electrophile responsible for the nitration of benzene?

a) HNO_3 b) $\overset{\oplus}{NO_2}$ c) $\overset{\oplus}{NO_3}$ d) $\overset{\oplus}{NO}$

6) ( ) The most stable conformation of the compound below (all methyl groups are *cis* to each other) has a) All methyl groups axial, b) All methyl groups equatorial, c) Equatorial methyl groups at C-1 and C-2, d) Equatorial methyl groups at C-2 and C-4.



7) ( ) Which structures are aromatic? a) II and III, b) III and IV, c) I and III, d) II and IV.



I II III IV

8) ( ) Which compound has a sharp IR absorption at 1710 cm^{-1} and a broad band at 3300 cm^{-1}?

a) $CH_3\overset{O}{\overset{\|}{C}}OH$ b) CH_3CH_2OH c) $CH_3\overset{O}{\overset{\|}{C}}CH_3$ d) CH_3OCH_3

9) ( ) Which region in the IR spectrum could be used to distinguish between benzene and cyclohexane?
a) 3000 cm^{-1} b) 1600 cm^{-1} c) 1680-1750 cm^{-1} d) 3200-3600 cm^{-1}

10) ( ) Which of the following statements concerning the effect of a trifluoromethyl group, CF_3, on an electrophilic aromatic substitution is true?
I. The CF_3 group will activate the ring; II. The CF_3 group will deactivate the ring;
III. The CF_3 group will be a *meta* director; IV. The CF_3 group will be an *ortho*, *para* director.
a) I and III b) I and IV c) II and III d) II and IV.

11) ( ) The separation of a racemic mixture into the pure enantiomers is termed
a) Racemization, b) Isomerization, c) Resolution, d) Equilibrium.

to be continued --

國立中山大學100學年度碩士班招生考試試題

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12) ( ) Which of the following statements pertaining to an SN2 reaction are true?

I. The rate of reaction is independent of the concentration of the nucleophile.

II. The nucleophile attacks carbon on the side to the molecule opposite the group being displaced.

III The reaction proceeds with simultaneous bond formation and bond rupture.

IV Partial racemization of an optically active substrate results.

a) I and IV b) I, III and IV c) II and III d) All

13) ( ) All the following groups are activating *ortho, para* directors when attached to a benzene ring except a) $-OCH_3$ b) $-NHC(=O)CH_3$ c) $-Cl$ d) $-N(CH_3)_2$.

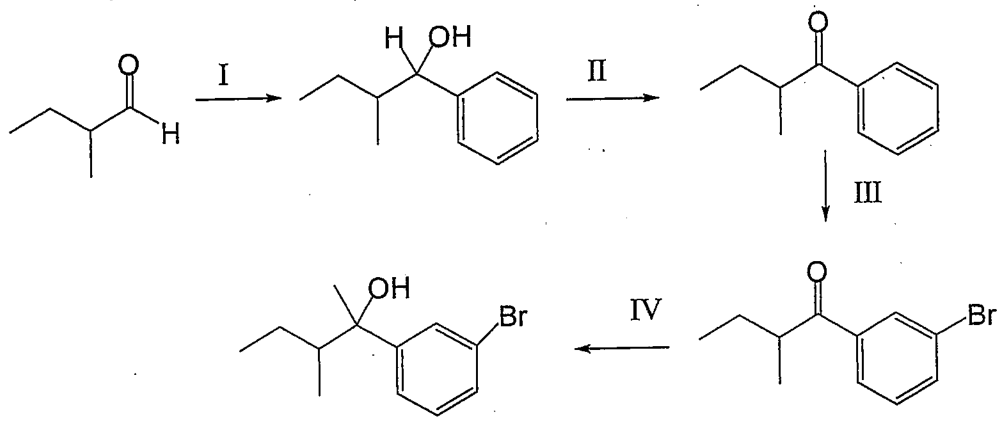
14) ( ) 2,3-pentdiene, $CH_3CH=CH=CHCH_3$, is a) A planar substance, b) A conjugated diene, c) An allene, d) A substance capable of *cis-trans* isomerism.

15) ( ) Which alkyne yields butanoic acid ($CH_3CH_2CH_2CO_2H$) as the only organic product on treatment with ozone followed by hydrolysis? a) 1-Butyne b) 4-Octyne c) 1-Pentyne d) 2-Hexyne.

16) ( ) Which is not a step in the mechanism of a chain growth (addition) polymerization?

a) Initiation b) Propagation c) Proliferation d) Termination.

(Questions 17) - 20)) There are four reagents I ~ IV required to perform the reaction scheme below



a) Periodinane; b) PhMgBr; c) CH_3OH/H^+; d) NaOH, heat; e) $LiAlH_4$ in ether, then H_3O^+; f) $Br_2/FeBr_3$

17) ( ) Chose the right reagents I from the above reagent lists from a) to f).

18) ( ) Chose the right reagents II from the above reagent lists from a) to f).

19) ( ) Chose the right reagents III from the above reagent lists from a) to f).

20) ( ) Chose the right reagents IV from the above reagent lists from a) to f).

2. (Total: 30%) Most of organic reactions are initialized by the nucleophilic attack of electron-rich (nucleophiles) to electron-poor (electrophiles) groups. The initial nucelophilic attacks are then followed by various bond-forming and bond-breaking steps to result in the final reaction products. Typical example can be illustrated by that under attacks of versatile nucleophilic reagents, simple alkyl and aryl halides result in different substitution and/or elimination products dependent on the experimental conditions. Inter-conversions of carobonyl compounds under the attacks of different nucleophilic reagents can be also regarded as the nucleophilic substitution reactions. The following statements in a) ~ d) relate to different previous experimental results concerning the reactions between nucleophiles and electrophiles. Explain it.

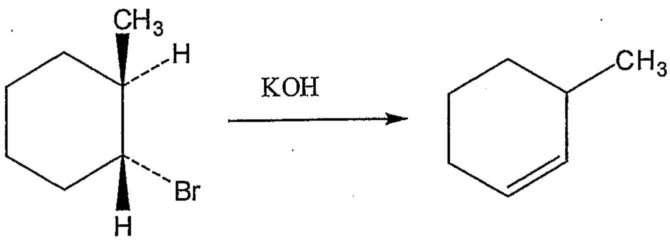
to be continued --

國立中山大學100學年度碩士班招生考試試題

科目：有機化學【材光系碩士班甲組】

a) (6 %) Sodium ethoxide (CH_3CH_2ONa) reacted with methyl bromide with a SN2 substitution mechanism. However, no reaction would occur when sodium ethoxide reacted with phenyl bromide (C_6H_5-Br). Explain it.

b) (9 %) *trans*-1-Bromo-2-methylcyclohexane yields the non-Zaitsev elimination product 3-methylcyclohexene on treatment with KOH. Explain why E2 reaction proceeds to give the specific product below?



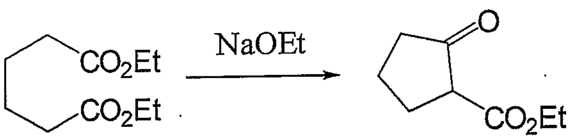
trans-1-Bromo-2-methylcyclohexane 3-methylcyclohexene

c) (9%) Interconversions of carboxylic acid derivatives by nucleophiles undergoes with the reactivity sequence of acid chloride (R-CO-Cl) > acid anhydride (RC(=O)OC(=O)R') > ester (RCOOR') > amide (RCONR'R"). Explain it.

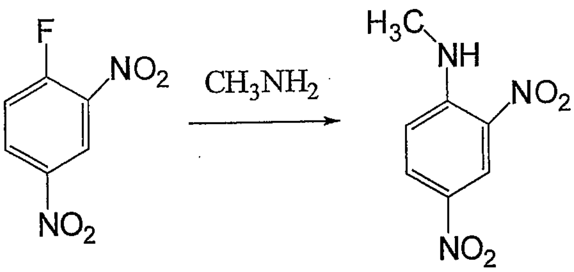
d) (6 %) Methyl trifluoroacetate, $CF_3CO_2CH_3$, is more reactive than methyl acetate, $CH_3CO_2CH_3$, in nucleophilic acyl substitution reactions. Explain it.

3. Write detailed mechanistic steps for the following transformations? (Total: 30 %, each 5 %)

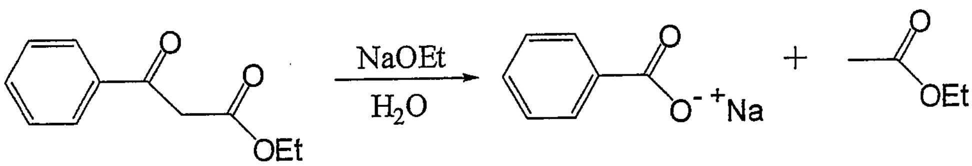
a) (5 %)



b) (5 %)



c) (5 %)



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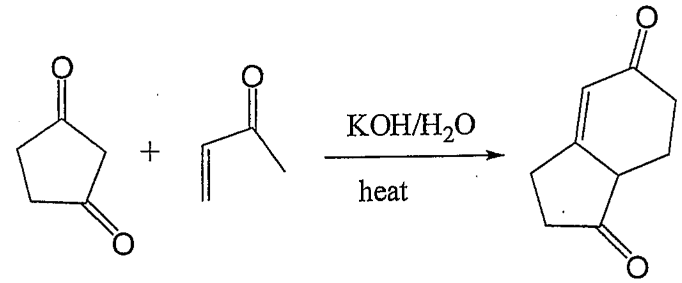
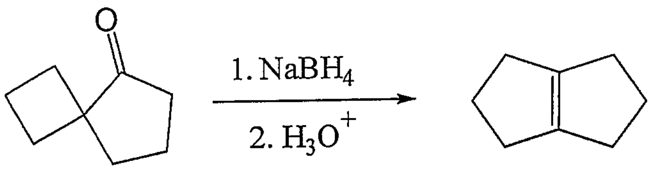
科目：有機化學【材光系碩士班甲組】

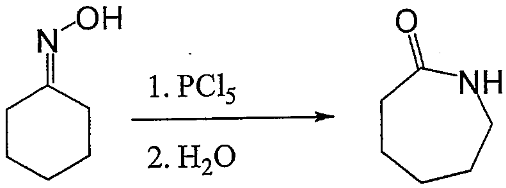
d) (5 %)



e) (5 %)



f) (5 %)



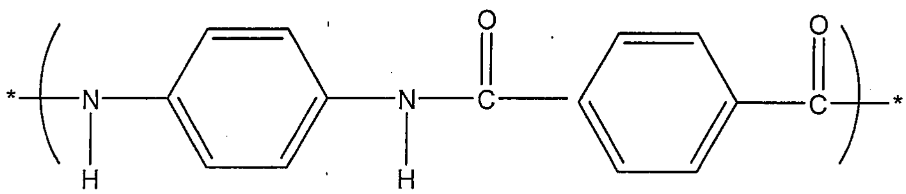
國立中山大學100學年度碩士班招生考試試題

科目：物理化學【材光系碩士班甲組】

1. Given the van der Waals constants for ethane gas as $a = 5.562$ L^2 bar/mol^2, $b = 0.06380$ L/mol, for 10.0 mol of ethane at 300 K and under 30 bar, where $R = 0.08314$ L-bar/K-mol (20%, each 5%)
   (a) find the second virial coefficient B at this temperature.
   (b) calculate the compressibility factor Z from the first two terms.
   (c) estimate the approximate molar volume from Z.
   (d) what is its Boyle temperature T_B?

2. When 3.0 mol O_2 is heated at a constant pressure of 3.25 atm, its temperature increases from 260 K to 285 K. Given that the molar heat capacity of O_2 at constant pressure is 29.4 J K^{-1} mol^{-1}, calculate q, ΔH, and ΔU. (15%, each 5%)

3. Some polymers can form liquid crystal mesophases with unusual physical properties. For example, liquid crystal Kevlar (as following picture) is strong enough to be the material of choice for bulletproof vests and is stable at temperatures up to 600 K. What molecular interactions contribute to the formation, thermal stability, and mechanical strength of liquid crystal mesophase in Kevlar? (5%)



4. From their atomic numbers and mass numbers, decide whether the following nuclei are likely to have zero, half-integral or integral spin: (a) ^{18}O, (b) ^{10}B, (c) ^{13}C, (d) ^{14}N, (e) ^{19}F (10%, each 2%)

5. The first generally available NMR spectrometer operated at a frequency of 60 MHz; today it is also common to use a spectrometer that operates at 600 MHz. (a) What are the relative population differences of ^{13}C spin states in these two spectrometers at 25 °C (4%)? What are the relative values of the chemical shifts observed for nuclei in these spectrometers in terms of (b) δ value (3%), (c) frequencies (3%)? (10%)

6. Which of the following molecules may show infrared absorption spectrum or Raman spectrum? (a) H_2, (b) HCl, (c) CH_4, (d) CH_3Cl, (e) CH_3CH_3 (10%, each 2%)

國立中山大學100學年度碩士班招生考試試題

科目：物理化學【材光系碩士班甲組】

7. Derive the foramtion of CH_4 from the thermal decomposition of acetaldehyde

$CH_3CHO \xrightarrow{k_{obs}} CH_4(g) + CO(g)$

A proposed mechanism is

$CH_3CHO \rightarrow CH_3 + CHO$ (k_1) (10%)

$CH_3 + CH_3CHO \rightarrow CH_4 + CH_3CO$ (k_2)

$CH_3CO \rightarrow CH_3 + CO$ (k_3)

$2CH_3 \rightarrow C_2H_6$ (k_4)

8. The Arrhenius equation $k = A\exp(-E_a / RT)$

(a) Sketch a plot of $\ln(k)$ as a function of $(1/T)$ and indicate A and E_a, on your graph (10%, each 5%)

(b) The rate constant for the decomposition of a certain substance is 2.17 L/mols at 840 K and 0.035 at 730 K, Calculate E_a for the reaction

9. (a) Using the Gibbs - Helmoltz equation $\left[\frac{\partial}{\partial T}\left(\frac{\Delta G^0}{T}\right)\right] = \frac{-\Delta H^0}{T^2}$ to derive Van't Hoff equation

$\ln K_p = \ln K_p{}^0 - \frac{\Delta H^0}{R}(\frac{1}{T} - \frac{1}{T^0})$

(b) Given that ΔH^0 has an average value of - 69.8 kJ/mol over the temperature range 500 K to 700 K for the reaction described by $PCl_3(g) + Cl_2(g) \Leftrightarrow PCl_5(g)$

Estimate K_p at 700 K given taht $K_p = 0.0408$ at 500 K

(10%, each 5%)

國立中山大學100學年度碩士班招生考試試題

科目：工程數學【材光系碩士班乙組】

1. Find the general solution of $2y\dfrac{d^3y}{dx^3}+2(y+3\dfrac{dy}{dx})\dfrac{d^2y}{dx^2}+2(\dfrac{dy}{dx})^2=\sin x$ (15%)

2. Use Frobenius method to find the general solution of $x^2y''+6xy'+(6-4x^2)y=0$. (20%)

3. Find the eigenvalues, eigenfunctions and verify the orthogonality of the solution by direct calculation. $y''+\lambda y=0,\ \ y(\pi)=y(-\pi),\ \ y'(\pi)=y'(-\pi)$. (15%)

4. A surface is defined by $z=x^2+y^2$, calculate the surface are defined on the domain $0\le x^2+y^2\le 4$ (15%)

5. $f(x)=x,\quad -\pi\le x\le\pi,\quad f(x)=f(x+2\pi)$, solve
   (1) Fourier series,
   (2) complex Fourier sereis
   (20%, each 10%)

6. Solve nonhomogeneous boundary condition of heat equation

$$\frac{\partial u(x,t)}{\partial t}=c^2\frac{\partial^2 u(x,t)}{\partial x^2}$$

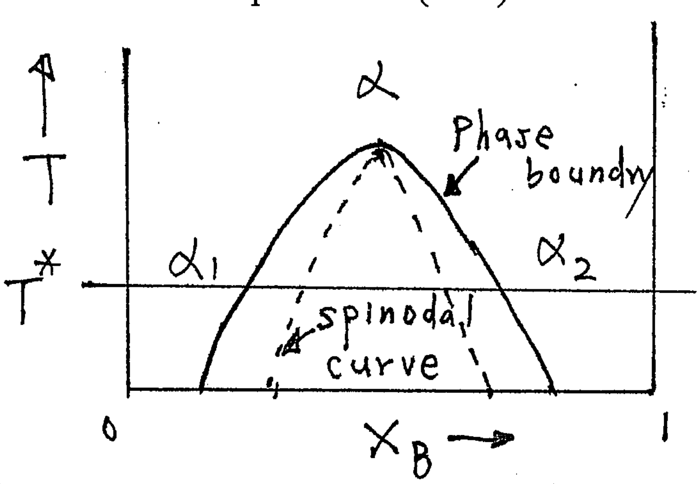
$u(0,t)=A_1, u(L,t)=A_2,\ u(x,0)=f(x)$, where $0<x<L,\ t>0$ (15%)

國立中山大學100學年度碩士班招生考試試題

科目：熱力學【材光系碩士班乙組】

請於答案卷上依序作答，清楚標明題號，計算題的答案整理標示於題末

1. Describe the meaning of state function and give three thermodynamic properties as state function. (10%)
2. One mole pure liquid copper at 1600 °C mixed with nine mole of pure liquid iron at 1600 °C and formed a homogeneous liquid solution. This is an endothermic reaction. The activity of copper will be greater than atomic fraction of copper or less than; and explain your answer. (10%)
3. According to the following thermodynamic data, calculate the enthalpy, entropy and Gibbs free energy of the reaction $Pb + 1/2\ O_2 = PbO$ at 1000 K. (30%)
   $H_{PbO(298)} = -219{,}000$ J/mole
   $S_{Pb(298)} = 65$ J/K mole
   $S_{PbO(298)} = 66.3$ J/K mole
   $S_{O2\ (298)} = 205$ J/K mole
   $C_{p,Pb(s)} = 23.6 + 9.75*10^{-3}T$ J/K from 298 K to T_m. Pb
   $C_{p,Pb(l)} = 32.4 - 3.1*10^{-3}T$ J/K from T_m. Pb to 1200 K
   $C_{p,PbO(s)} = 37.9 + 26.8*10^{-3}T$ J/K from 298 K to T_m. PbO
   $C_{p,O2(g)} = 29.96 + 4.18*10^{-3}T - 1.67*10^{5}\ T^{-2}$ J/K from 298 K to 3000 K
   $\Delta H_{m,\ Pb} = 4810$ J at $T_{m,\ Pb} = 600$ K
   $T_{m,\ PbO} = 1159$ K
4. One mole of N_2 gas is contained at 273 K and a pressure of 1 atm. The addition of 3000 J of heat to the gas at constant pressure cause 832 J of work to be done during the expansion. Calculate (a) the final state of the gas, (b) the values of ΔU and ΔH for the change of state and (c) the values of C_v and C_p for N_2. Assume that nitrogen behaves as an ideal gas, and that the above change of state is conducted reversibly. (25%)
5. According to the following phase diagram, plot the free energy curve at T* and distinguish the regions of stable equilibrium, metastable equilibrium and unstable equilibrium. (25%)



P.S. 4(a) 8%; (b) 7%; (c) 10%

國立中山大學100學年度碩士班招生考試試題

科目：光電概論【材光系碩士班丙組】

Electrostatic Fields

1. A hollow spherical shell carries charge density $\rho = \dfrac{k}{r^2}$ in the region $a \le r \le b$, as shown in Fig. 1.

   On the other regions, the carries charge density is zero.

   (a) Find the electric field intensity E and the potential V in the region of $r > b$. (10%)

   (b) Find E and V in the region of $a < r < b$. (10%)

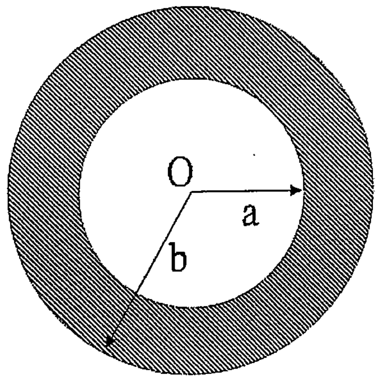


Fig. 1

2. The upper and lower conducting plates of a large parallel-plate capacitor are separated by a distance d and maintained at potentials V_o and 0, respectively (Fig. 2). Two dielectric slabs are placed between the two conducting plates. Dielectric slab A is placed over the lower plate with dielectric constant ε_{r1} and uniform thickness 0.8d. Dielectric slab B with a dielectric constant ε_{r2} is inserted between dielectric slab A and the upper plate. Assuming negligible fringing effect, determine

   (a) The potential and electric field distribution in the dielectric slab A. (10%)

   (b) The potential and electric field distribution in the dielectric slab B. (10%)

   (c) The surface charge densities on the upper and lower plates. (10%)

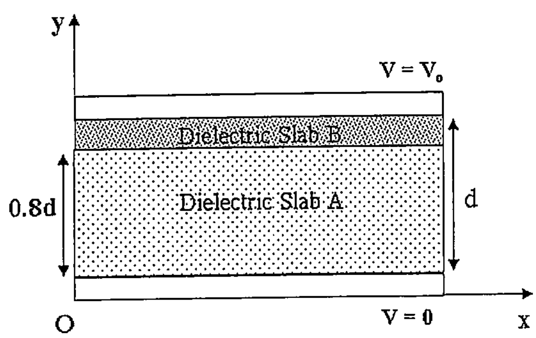


Fig. 2

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科目：光電概論【材光系碩士班丙組】

LED Operation

3. In semiconductors, the device containing a p-n junction for rectification is called a diode. When a diode is forward biased, a current flows through the device. The current consists of holes in the p region, and electrons in the n region, both moving toward the p-n junction. Electrons and holes meet and recombine in the vicinity of the junction, and then release energy in the form of photons of light. The device in which light is emitted in this way is termed a *light-emitting diode* or LED. The energy separation between the top of the valence band and the bottom of the conduction band is known as the bandgap energy E_g. Since the electron and holes will settle to the band edge before recombining, the energy of the emitting photon is therefore approximately equal to E_g. The number of emitting photons per unit time is related to the number of electrons entering the junction per unit time, i/e. Its optical power P_{opt} is expressed as

$$P_{opt} = \left[\frac{energy}{unit \quad time}\right] = \left[\frac{electrons}{unit \quad time}\right]\left[\frac{photons}{electrons}\right]\left[\frac{energy}{photons}\right] = \frac{i}{e}\eta h\nu,$$

where i is the electric current, η is the emission efficiency, h is the Plank constant ($h = 6.626\times10^{-34}$ J·sec.), ν is the frequency of the light, and e denotes the elementary charge, i.e., $e = 1.6\times10^{-19}$C. On the other hand, it has been shown that the dependence of current i on applied voltage V can be written as

$$i = i_o[\exp(\frac{eV}{\beta K_B T}) - 1],$$

where i_o is the reverse saturation current, K_B is the Boltzmann constant ($K_B = 1.38 \times 10^{-23}$ m^2 kg s^{-2} K^{-1}), T is the absolute temperature, and β is the diode ideality factor.

Now a GaAs LED connected with a battery V_s and a load resistor R is designed to generate an optical power of 30mW, as shown in Fig. 3. The bandgap of GaAs is 1.42eV. Assume that $V_s = 3.0$ Volt, T=293°K (room temperature), $\beta = 1$, $i_o = 1.0\times10^{-4}\mu$A, and $\eta = 0.6$. Please answer the following questions:

(a) What is the corresponding emission wavelength? (20%)

(b) Please determine the required load resistance. (30%)

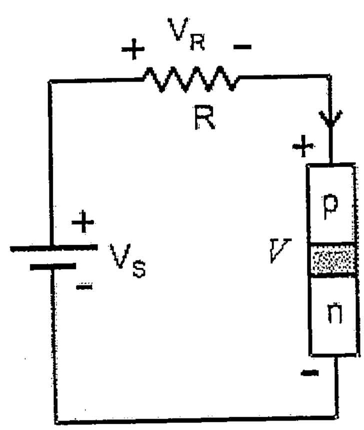


Fig. 3.

國立中山大學100學年度碩士班招生考試試題

科目：材料科學【材光系碩士班丙組】

(1) There are many methods which can increase the strength of a material. Give all the methods that you know, and explain the theory behind each method.
12 points

(2) By annealing, a heavily deformed material will be recrystallized. Describe how a recrystallized grain is nucleated from a deformed material. 8 points

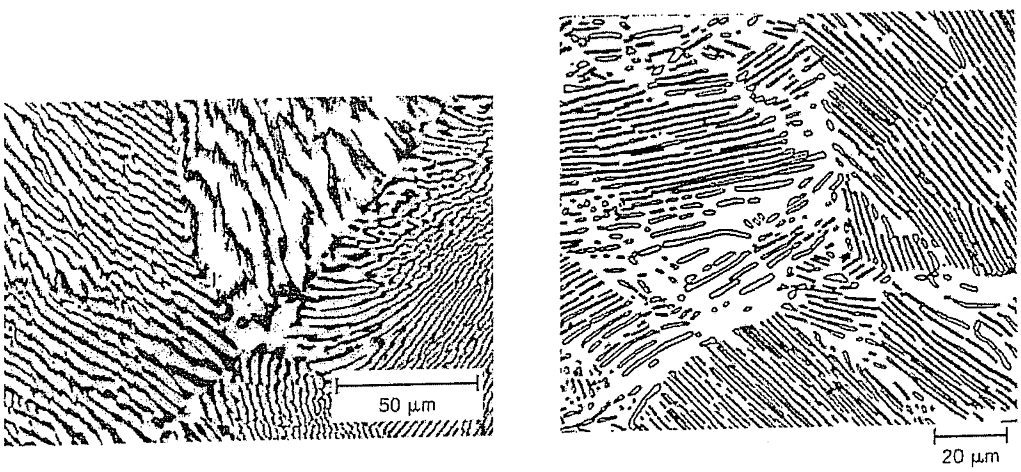
(3) What is the importance in knowing the resolved shear stress of a material when considering the deformation of the material? 9 points

(4) Give schematic drawings of one fcc and one bcc superlattice crystal structures.
6 points

(5) During solidification, different nucleation and growth conditions resulting in different solidification structures. Describe how nucleation and growth produce
(a) equiaxed grains, 5 points
(b) columnar grains. 5 points

(6) Explain what is meant by the term "coordination number". What is the coordination number of an atom in
(a) fcc structure, 3 points
(b) bcc structure. 3 points

(7) The micrographs shown below were taken from (a) a Pb- 61.9 wt% Sn alloy and (b) a plain carbon steel. Why so different alloys have such similar microstructures?
6 points



(a) (b)

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科目：材料科學【材光系碩士班丙組】

(8) Explain why five degrees of freedom is needed to describe a grain boundary.

8 points

(9) The diffusivities of metal A and B are very different. By joining metal A and B together, a diffusion couple is made. Discuss what may happen to this diffusion couple, when it is annealed, and interdiffusion between A and B occurs.

10 points

(10) Heterogeneous nucleation is always easier than homogeneous nucleation, why is this? Give your answer without containing any equation! 10 points

(11) Explain the following terms:

(a) stoichiometry, 3 points

(b) Schottky defect, 3 points

(c) hardenability, 3 points

(d) conjugate slip system, 3 points

(e) extrinsic semiconductor. 3 points